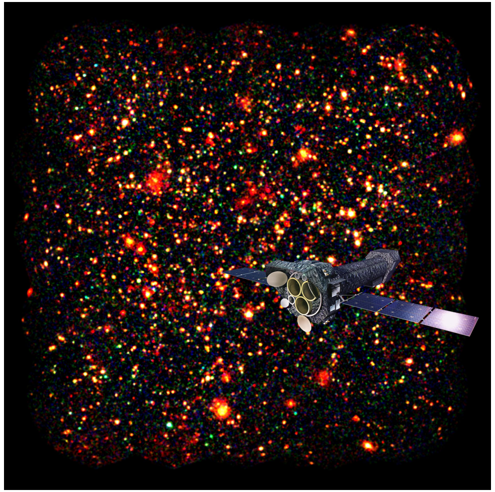
*Spectroscopic and photometric samples for **COSMOS/GOODS-S** fields and the **MOONS** future prospective for **SED** fitting studies*



Aix*Marseille université

Jorge Andrés Villa Vélez

Dr. Véronique Buat, Dr. Denis Burgarella,
Dr. Myriam A. Rodrigues, Dr. Mathieu Puech,
Dr. Héctor Flores
2019

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Outline

- **MOONS**
- Current **SSP** models
- New High-Resolution models in **CIGALE**
- Why **photometry + spectroscopy** is needed?
- **COSMOS** and **GOODS-S** fields catalog for **SED** fitting
- **Hα** and **[OIII]** subsamples: **CIGALE** emission line modeling

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MOONS

Multi Object Optical and Near-Infrared Spectrograph

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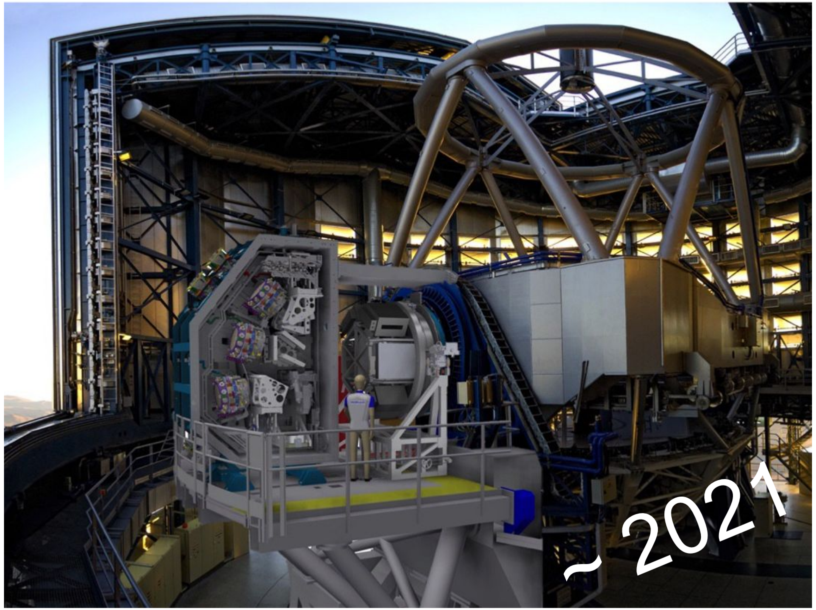
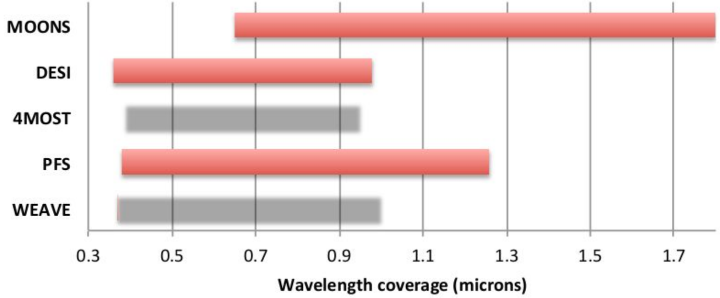
MOONS: Multi Object Optical and Near-Infrared Spectrograph





Requirement	Baseline Specification
Field-of-View	500 $arcmin^2$
Fibre multiplex per pointing	1000
Smallest target separation	<10"
Sky projectsd diameter of each fiber	1.0 arcsec
Wavelength coverage	0.65 - 1.8 micron
Observing modes	medium resolution (MR) and high resolution (HR)

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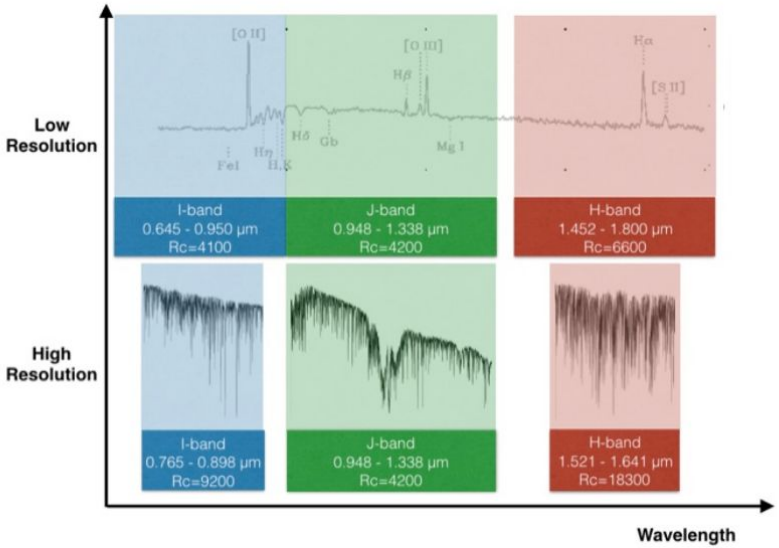
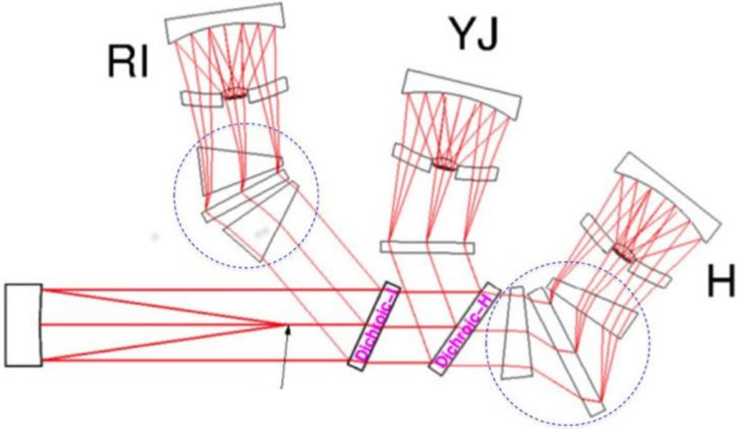
William Taylor, Michele Cirasuolo, Jose Afonso, Marcella Carollo, Chris Evans, et al., 2018

MOONS: Resolution Modes



MOONS-Wiki



William Taylor, Michele Cirasuolo, Jose Afonso, Marcella Carollo, Chris Evans, et al., 2018

Wavelength coverage 0.64-1.8µm

Medium-resolution mode
R ~4000-6000 (I, J, and H-band)

High-resolution mode
R~9200
R~4200
R~18300

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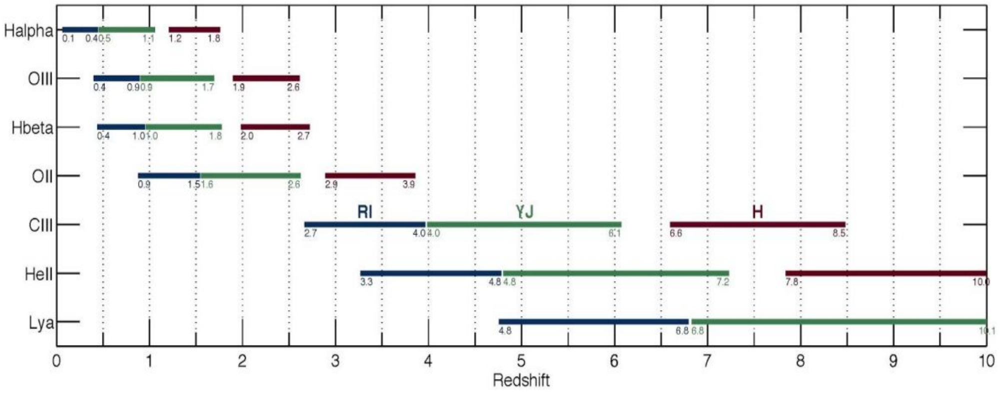
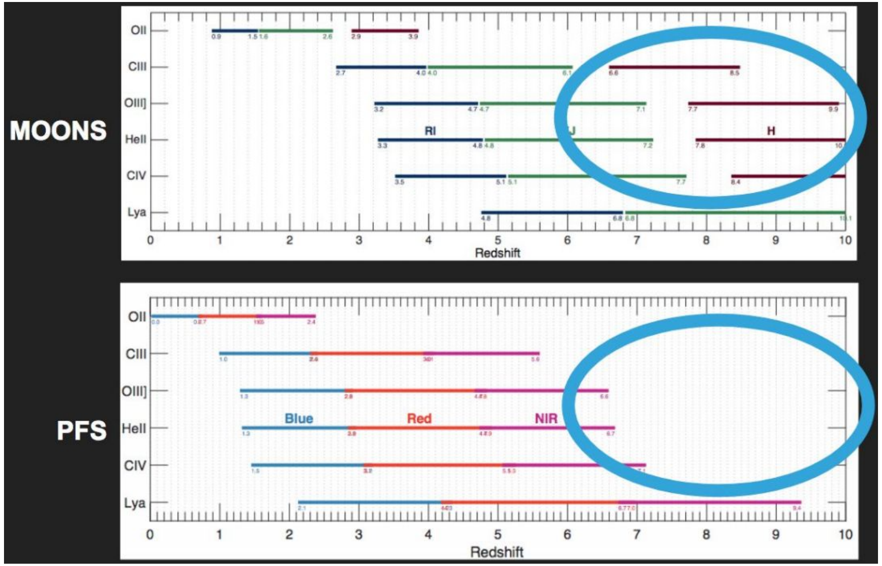
MOONS: Emission Line Coverage





MOONS-Wiki

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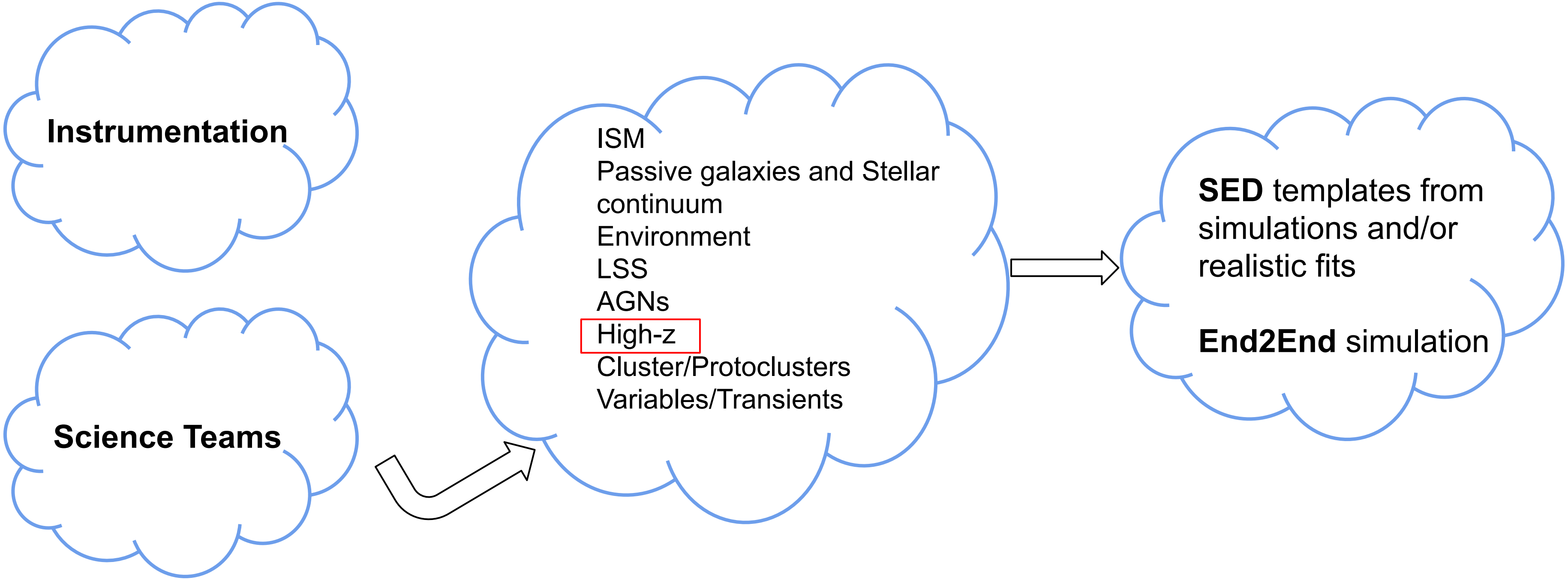
Jorge Andrés Villa Vélez

MOONS: Extragalactic Astronomy



MOONS: Extragalactic Astronomy

Stellar mass	10^{9}	$10^{10.5}$	$10^{11.5}$
Velocity dispersion	50km/s	120km/s	250km/s
SFH	Starbust | MS	Starbust | MS | Quiescent	MS | Quiescent
SFR			
Metallicity (Z_{sun})	0.5	0.5,1	0.5,1,2

Science Cases

- **SC1:** Galactic stellar archaeology
- **SC2:** Galaxy evolution in the redshift desert
- **SC3:** Large-scale structure
- **SC4:** Large-area galaxy surveys
- **SC5:** The first galaxies at the largest redshifts

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Simple Stellar Population High-Resolution Models

Stellar Models Libraries

UV and NIR extended

Empirical models

M11 **Pickles**-based: 2.5 Myr to 12 Gyr
1.15 - 10.62 [μm]
R~500
Sampling 5.0 Å

M11 **MARCS**-based: 3/7 to 15 Gyr
1.29 - 199.9 [μm]
R~20000
Sampling 0.065 Å

Stellar library models

M11 **STELIB**-based: 30 Myr to 15 Gyr
1.01 - 9.3 [μm]
R~3.1-3.4Å (FWHM)
Sampling 0.5 Å

M11 **MILES**-based: 55 Myr/ 6.5/55 Gyr Myr to 15 Gyr
0.1/0.35 - 0.74/199.9 [μm]
R~2.54Å (FWHM)
Sampling 0.9 Å

M11 **ELODIE**-based: 3/55 Myr to 12/15 Gyr
0.1/ 0.39 - 0.68 [μm]
R~0.55Å (FWHM)
Sampling 0.2 Å

Current models

M05 models: 1000 yr - 15 Gyr
0.09 - 1600 [μm]

BC03 models: 0.0 - 20 Gyr
91 [Å] - 160 [μm]
R~1000

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Stellar Models Libraries

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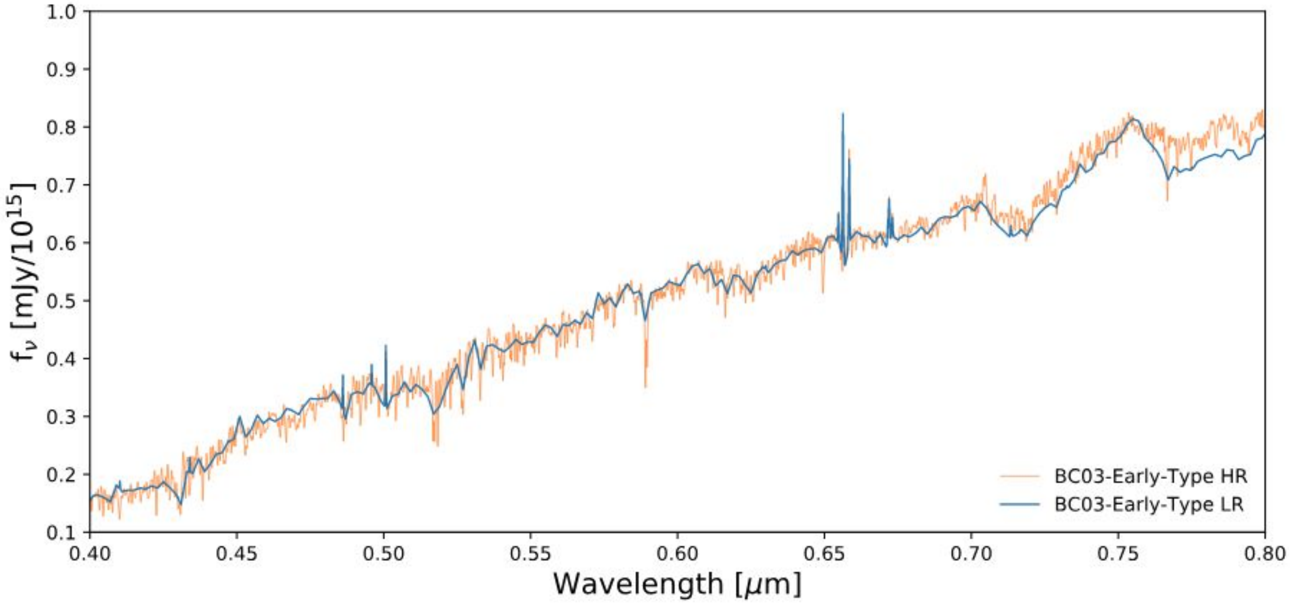
Samples: Low- and-High Resolution BC03 models



BC03 LR models:
λ/Δλ ~ 200-500

BC03 HR models:
λ/Δλ ~ 2000

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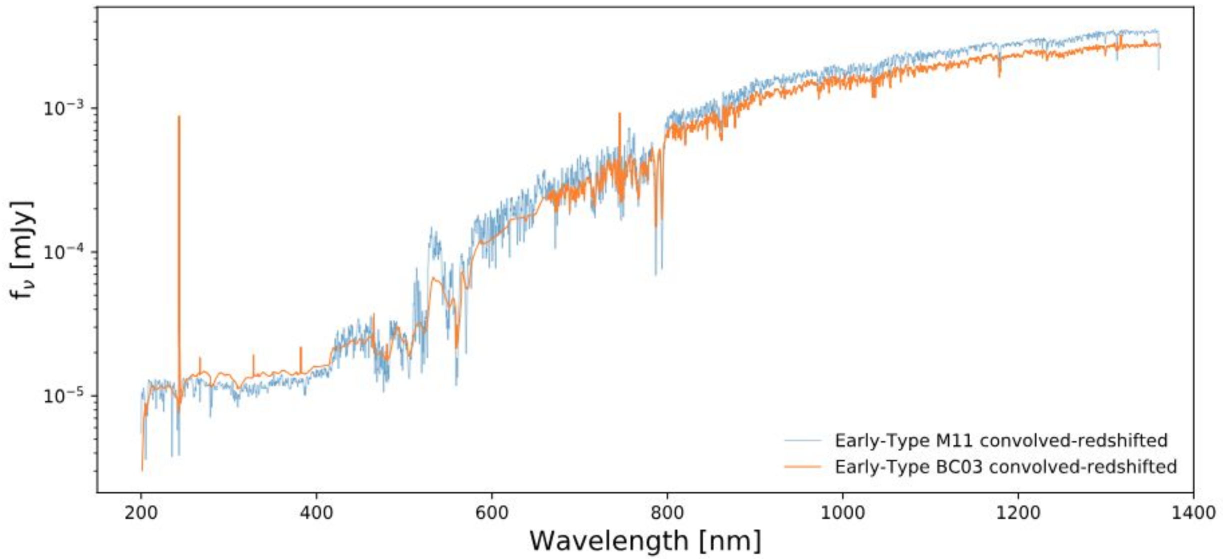
Samples: CIGALE-MOONS version



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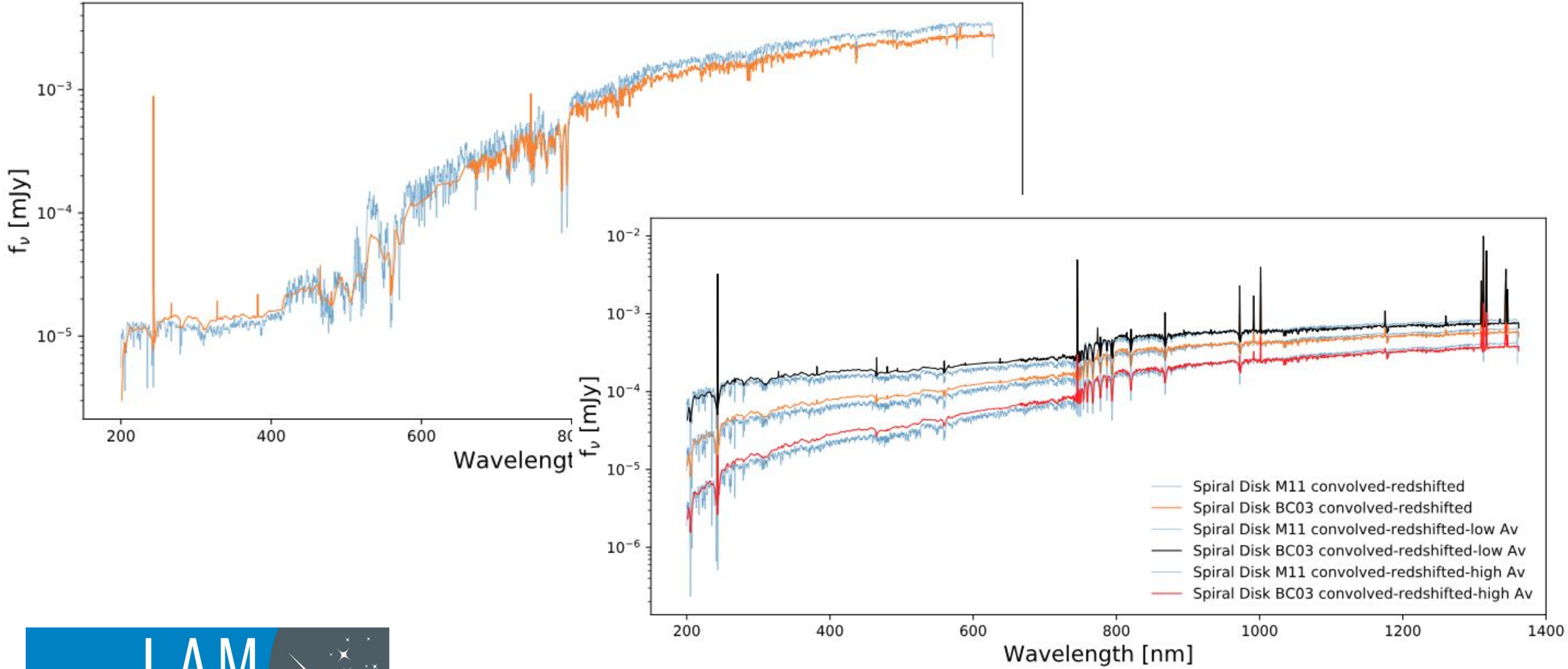
Samples: CIGALE-MOONS version



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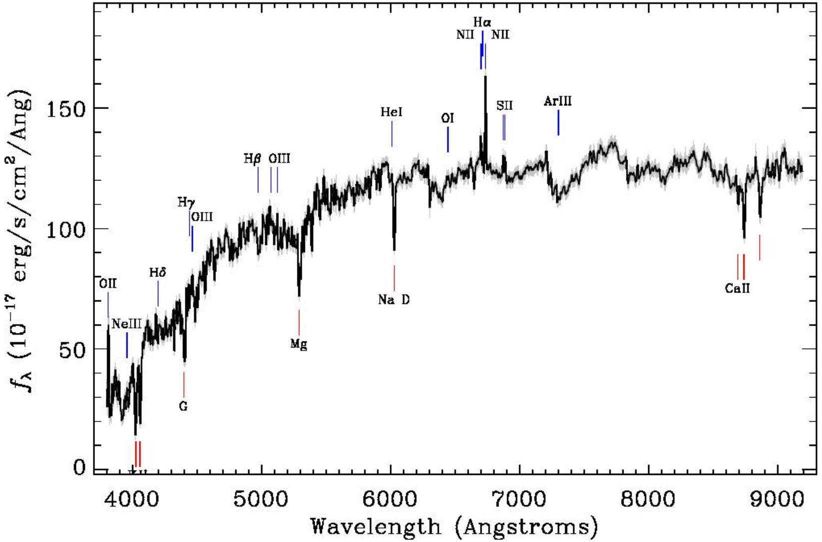
Dust Attenuation & SFRs:
Photometry +
3D-HST Spectroscopy

SED Photometry + Spectroscopy: Relevance

Issues: Spectroscopic data overwhelms the photometric. Hard to find a reliable likelihood for the bayesian methods!. Alternatively, Monte-Carlo methods to fit both. Deep-learning methods. (**Chevallard & Charlot 2016; Fossati et al. 2018; Aufort Ph.D. thesis**)



The Undergraduate ALFALFA Team

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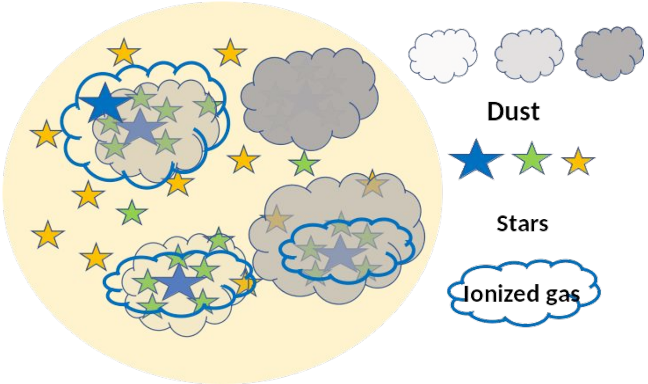
My Goal: To study differences between the attenuation of nebular lines and continuum. Variations between young and old stellar populations, metallicity, SFRs …
Simultaneous fit of photometric and spectroscopic data ensures a full consistency and helps us to measure a differential attenuation by assuming a simple attenuation law as **Calzetti et al. (2000)** and then compare it to the SFR obtained for UV, IR and emission lines.



Buat et al.,

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Alternative approach (**already implemented in CIGALE**)**:** Add **EWs** or **emission line fluxes** to the photometric data to constrain the different stellar populations and amount of dust attenuation avoiding the oversampling of full spectra. (**Buat et al., 2018; Boquien et al., 2019**)

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Fields: COSMOS

3D-HST Momcheva et al., 2016: Redshift + emission lines

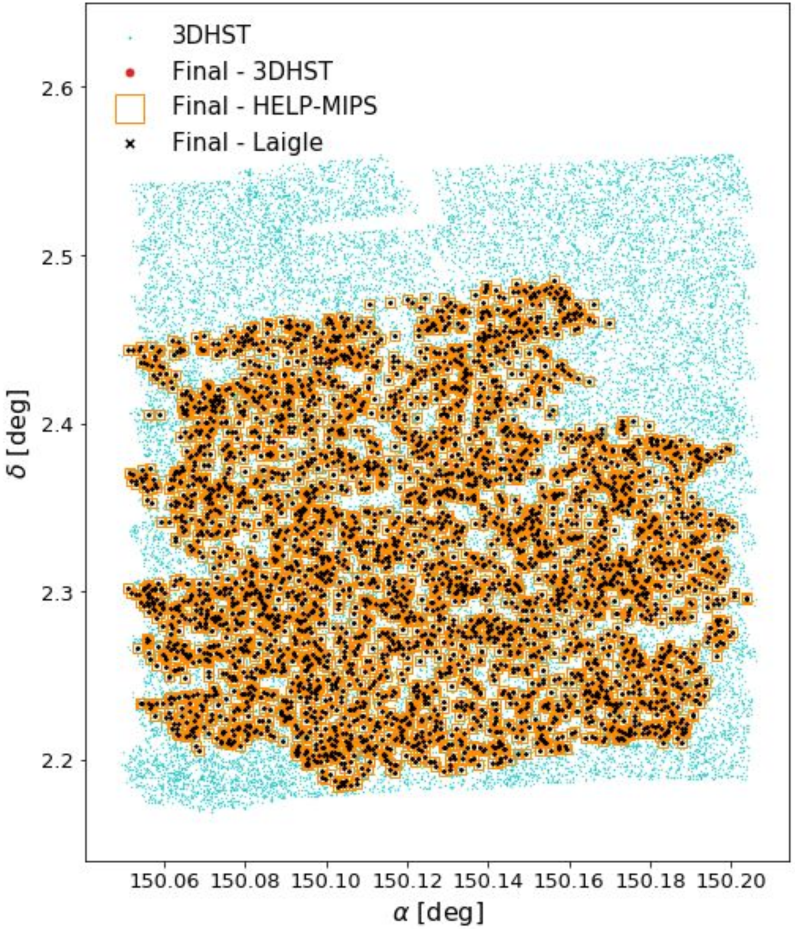
Laigle et al., 2016 photometry: U B V r i z J H Ks

HELP-project catalog : NUV
IRAC (1,2,3,4)
Spitzer 24µm
PACS (100µm and 160µm)
SPIRE (250µm, 350µm, 500µm)

Extra-check: Jin et al., 2018 data (PACS (100 and 160) and SPIRE (250, 350, 500)

PEP data for (PACS (100 and 160)

HELP-project data

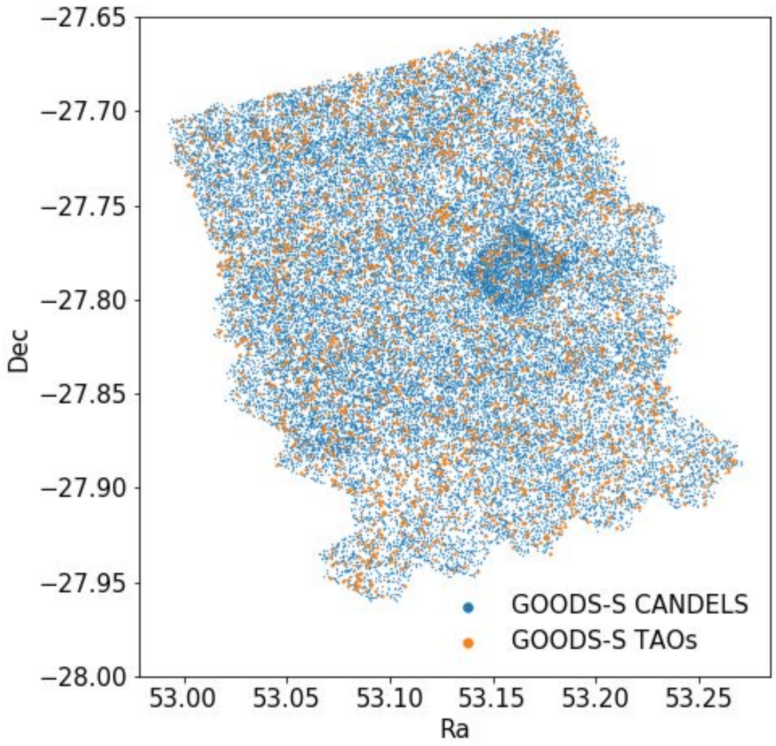


Fields: GOODS-S

3D-HST Momcheva et al., 2016: Redshift + emission lines

CANDELS Guo et al., 2013: UVIMOS F435W F606W F755W F814W F850LP F098M F105W F125W F160W ISAAC-Ks Spitzer 24μm IRAC(1,2,3,4)

PEP catalog Lutz et al., 2011: PACS (70μm, 100μm and 160μm) SPIRE (250μm, 350μm, 500μm)



Extra-check: Jin et al., 2018 data (PACS (100 and 160) and SPIRE (250, 350, 500)

PEP data for (PACS (100 and 160)

HELP-project data

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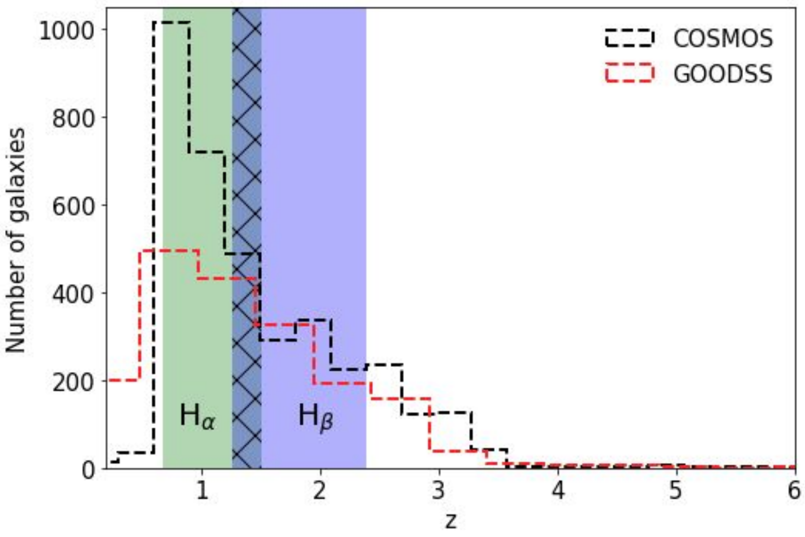
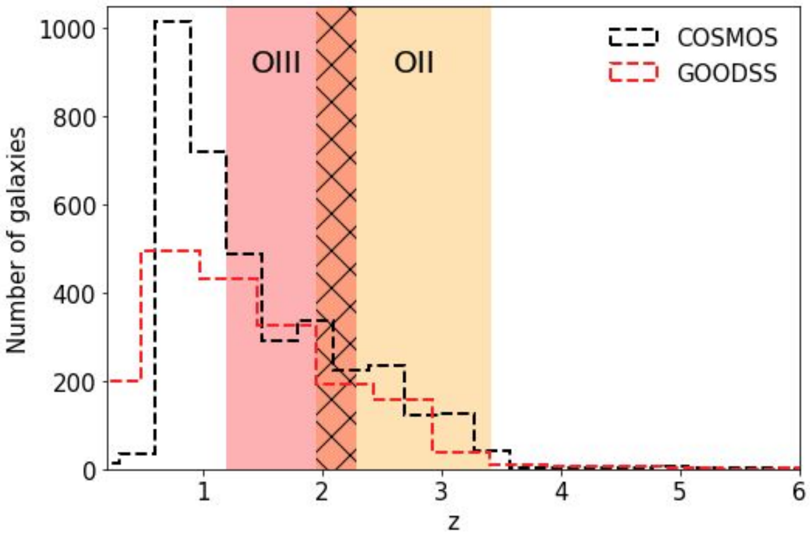
Final samples: COSMOS and GOODS-S





COSMOS	**3676 objects**
GOODS-S	**1877 objects**

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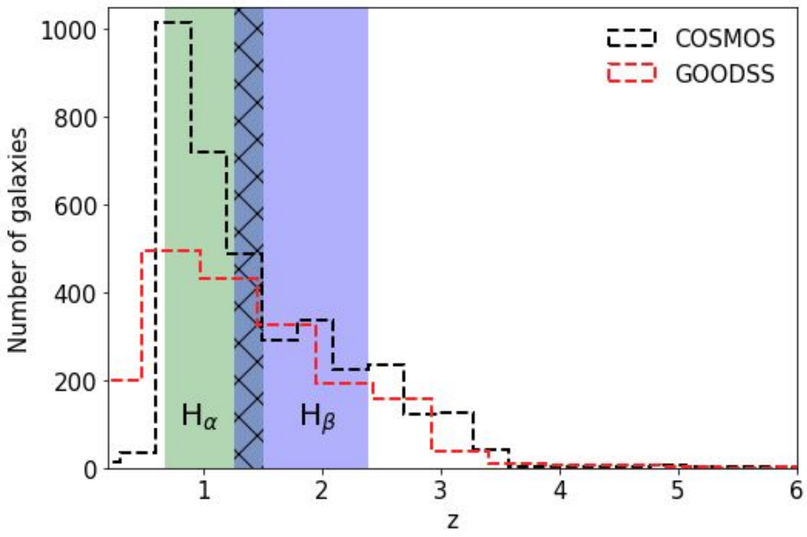
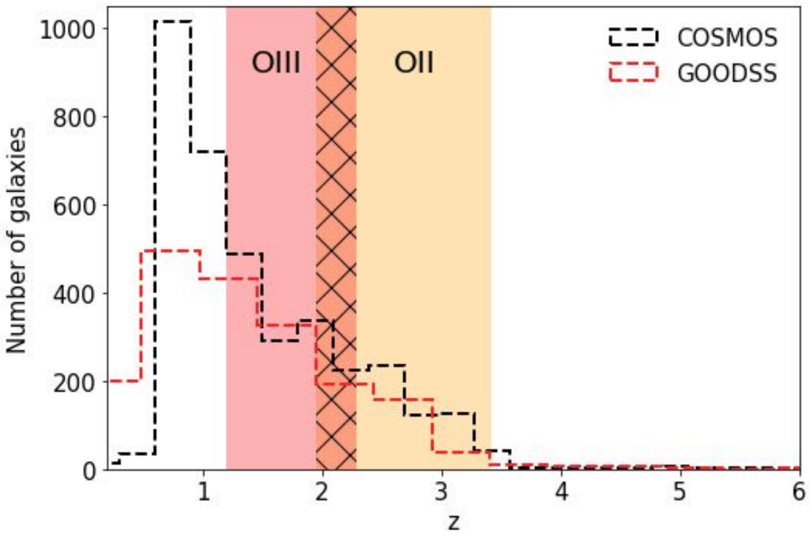
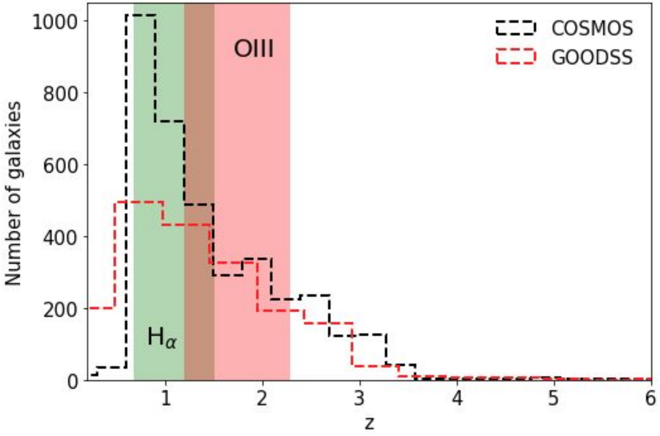
Final samples: COSMOS and GOODS-S





SNR > 3 for Hα and OIII
At least PACS 100 μm and 160 μm

Final samples: COSMOS and GOODS-S



SNR > 3 for Hα and OIII
At least PACS 100 µm and 160 µm

Bands	Good Data	Percentage (%)
galex.NUV	3	75.00
cfht.megacam.u	4	100.00
subaru.suprime.B	4	100.00
subaru.suprime.V	4	100.00
subaru.suprime.r	4	100.00
subaru.suprime.i	4	100.00
subaru.suprime.z	4	100.00
subaru.hsc.y	4	100.00
UKIRT_WFCJ	4	100.00
cfht.wircam.H	4	100.00
WFCAM_K	4	100.00
IRAC1	4	100.00
IRAC2	4	100.00
IRAC3	3	75.00
IRAC4	2	50.00
spitzer.mips.24	4	100.00
herschel.pacs.100	4	100.00
herschel.pacs.160	4	100.00
herschel.spire.PSW	0	0.00
herschel.spire.PMW	0	0.00
herschel.spire.PLW	0	0.00
Ha	4	100.00
Hb	4	100.00
OIII	4	100.00

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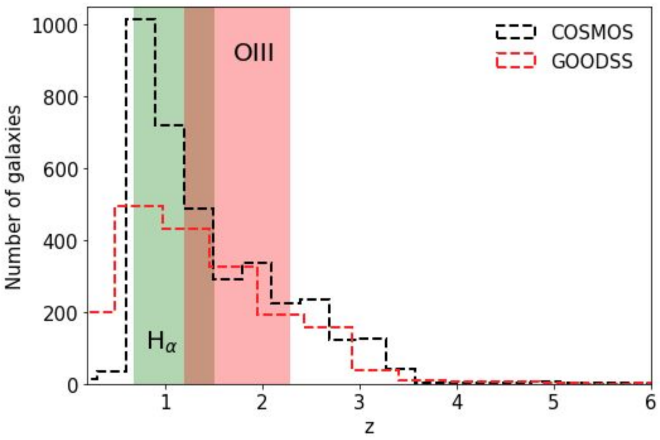
Final samples: COSMOS and GOODS-S

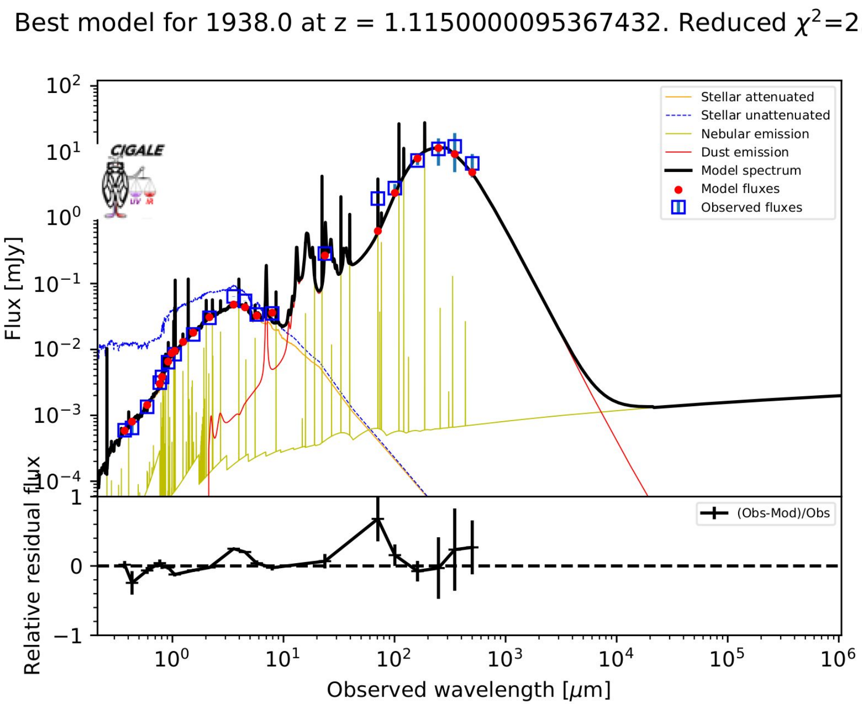


SNR > 3 for Hα and OIII
At least PACS 100 μm and 160 μm

Bands	Good Data	Percentage (%)
galex.NUV	3	75.00
cfht.megacam.u	4	100.00
subaru.suprime.B	4	100.00
subaru.suprime.V	4	100.00
subaru.suprime.r	4	100.00
subaru.suprime.i	4	100.00
subaru.suprime.z	4	100.00
subaru.hsc.y	4	100.00
UKIRT_WFCJ	4	100.00
cfht.wircam.H	4	100.00
WFCAM_K		
IRAC1		
IRAC2		
IRAC3		
IRAC4		
spitzer.mips.24		
herschel.pacs.100		
herschel.pacs.160		
herschel.spire.PSW		
herschel.spire.PMW		
herschel.spire.PLW		
Ha		
Hb		
OIII		

Bands	Good Data	Percentage (%)
UVIMOS	22	100.00
hst.wfc.F435W	22	100.00
hst.wfc.F606W	22	100.00
hst.wfc.F755W	22	100.00
hst.wfc.F814W	22	100.00
ACS_F850LP	22	100.00
WFC3_F098M	8	36.36
WFC3_F105W	13	59.09
hst.wfc3.F125W	21	95.45
hst.wfc3.F160W	22	100.00
ISAACKs	21	95.45
spitzer.irac.ch1	22	100.00
spitzer.irac.ch2	22	100.00
spitzer.irac.ch3	22	100.00
spitzer.irac.ch4	22	100.00
spitzer.mips.24	22	100.00
herschel.pacs.70	22	100.00
herschel.pacs.100	22	100.00
herschel.pacs.160	22	100.00
herschel.spire.PSW	22	100.00
herschel.spire.PMW	13	59.09
herschel.spire.PLW	9	40.91
Ha	22	100.00
Hb	19	86.36
OIII	22	100.00

Fields: SED fitting with CIGALE



Avoid bad photometric data

Guarantee an homogenous sample for both fields

Explore a wide range of parameters

Modify recipes for attenuation laws

Calibrate SFRs using Lines + Continuum

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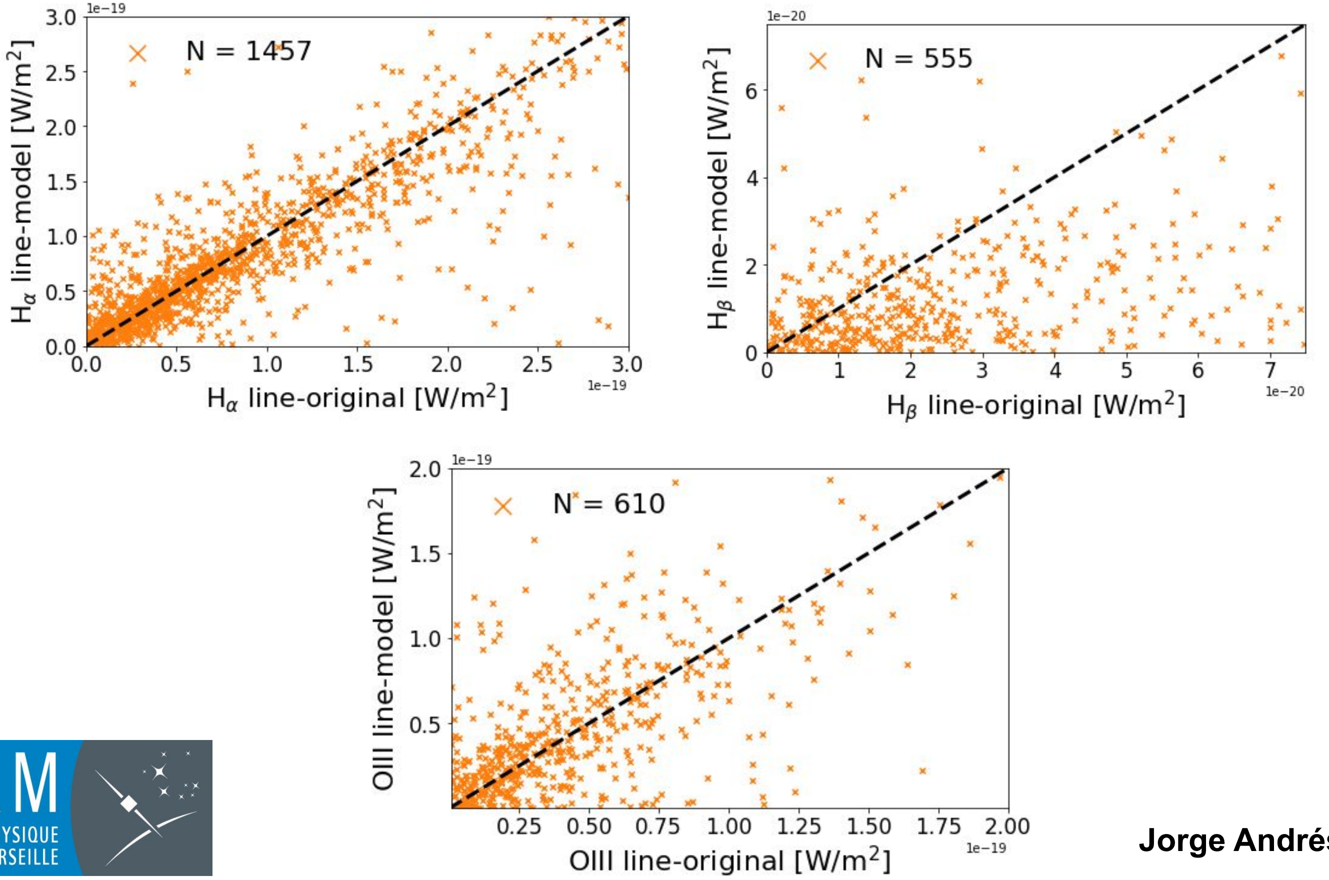
Subsample: Emission lines



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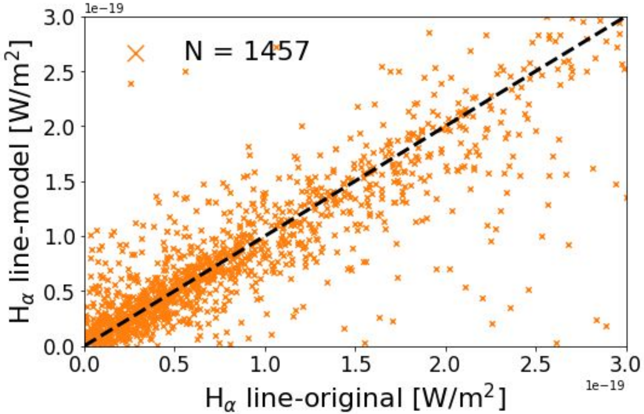
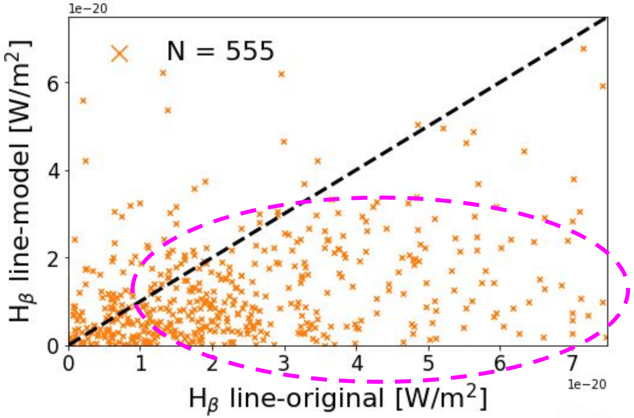
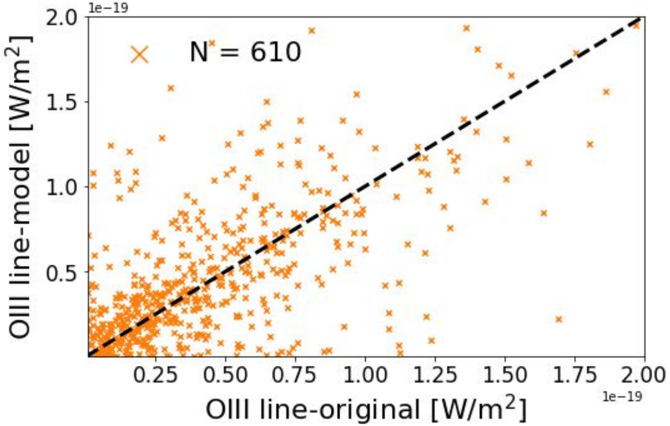
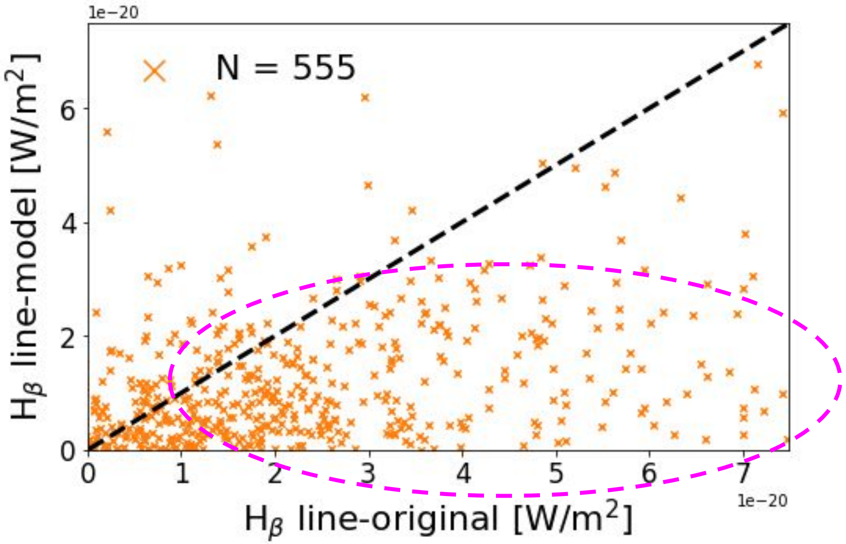






Dust Attenuation: My Ph.D. Thesis



Classical recipe or starburst:

Proposed by **Calzetti et al., 2000** based on attenuation continuum ratio fixed i.e. E = 0.44

CF00 recipe:

Proposed by **Charlot and Fall, 2000** based on different attenuations for the birth cloud and the ISM

Already implemented in CIGALE!

Boquien et al., 2019

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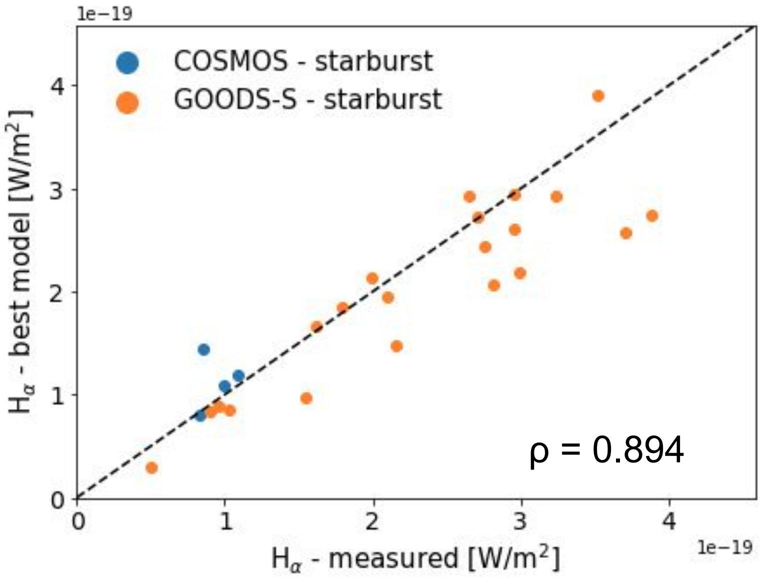
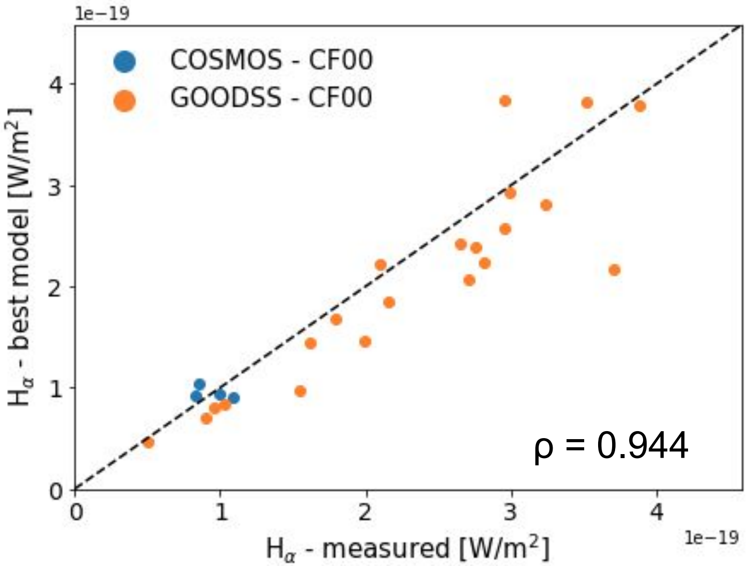
Sub-sample: Hα and [OIII] prediction

Modified Starburst model
Derived from Calzetti et al., 2000 law



Modified CF00 model
Proposed by Charlot & Fall, 2000



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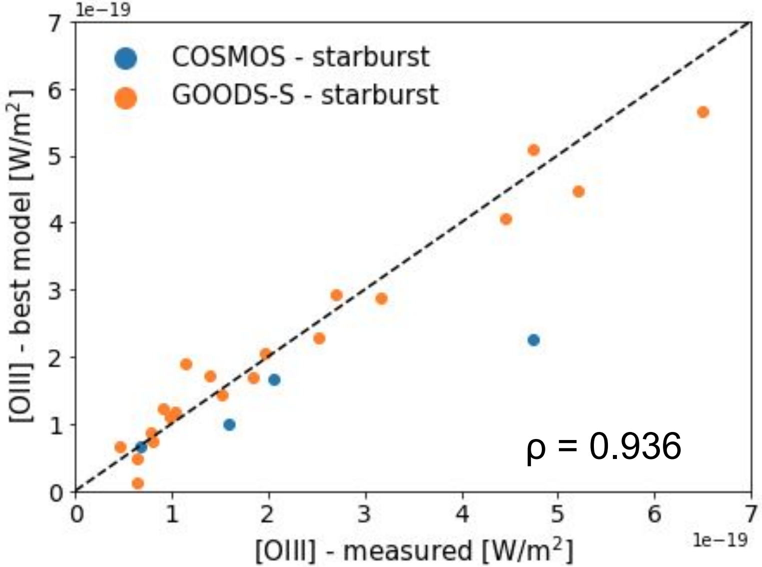

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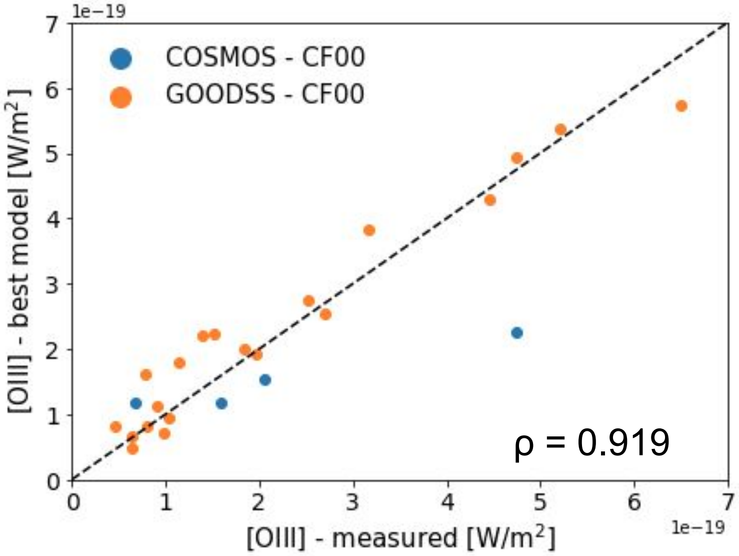

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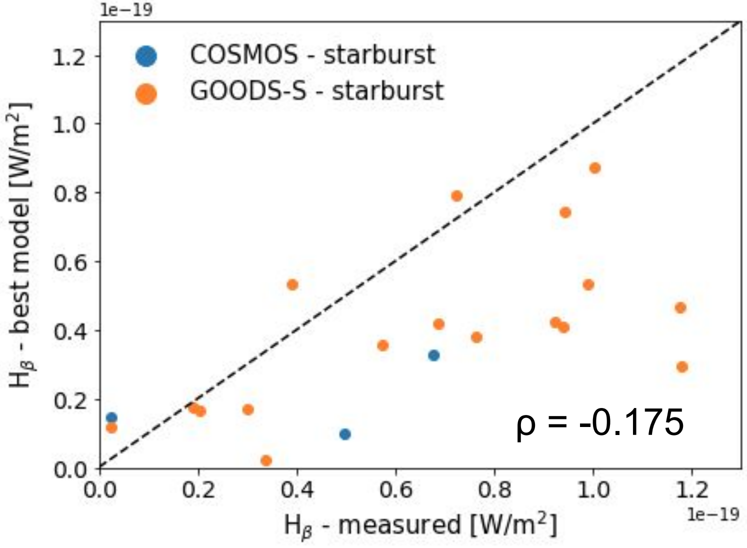
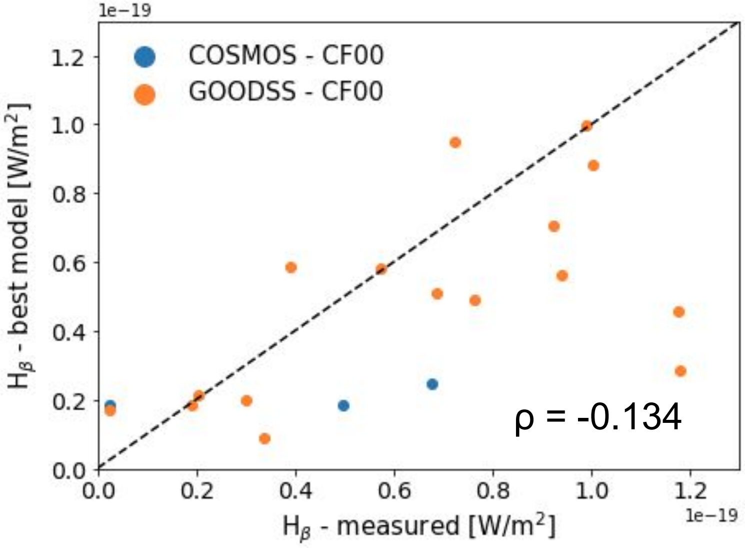
Sub-sample: Hβ prediction

Modified Starburst model
Derived from Calzetti et al., 2000 law



Modified CF00 model
Proposed by Charlot & Fall, 2000



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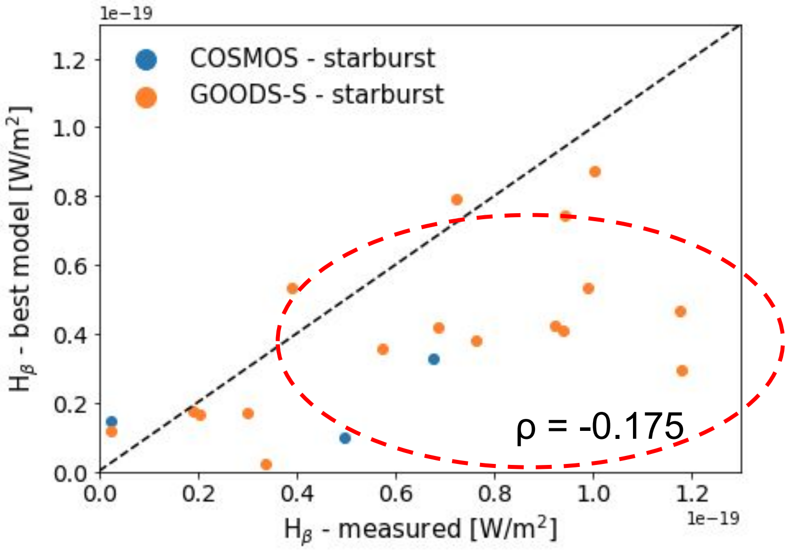

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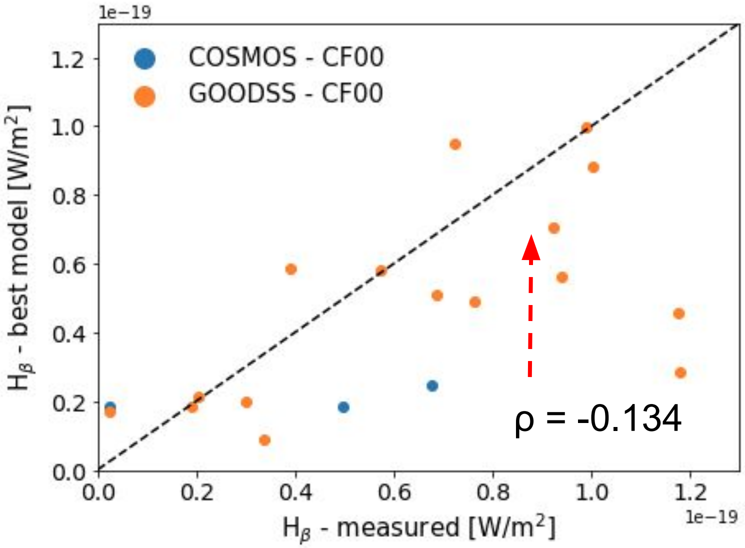

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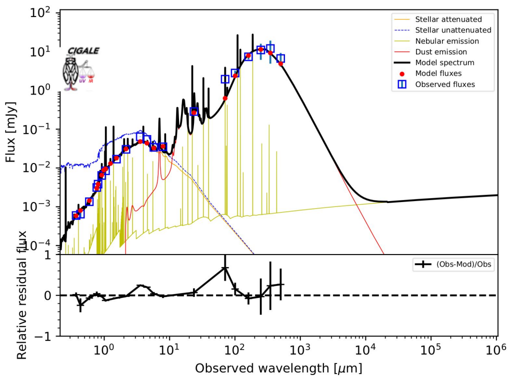
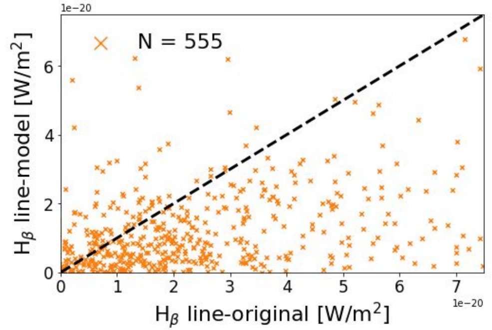
Jorge Andrés Villa Vélez

Current and Future work ...





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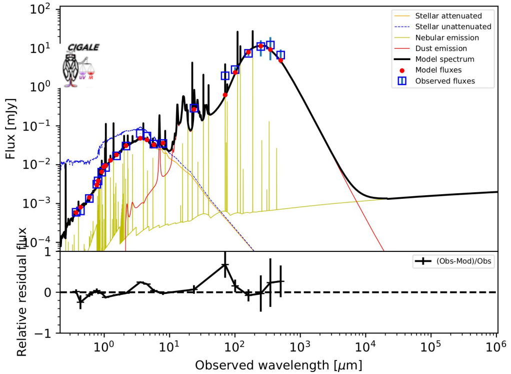
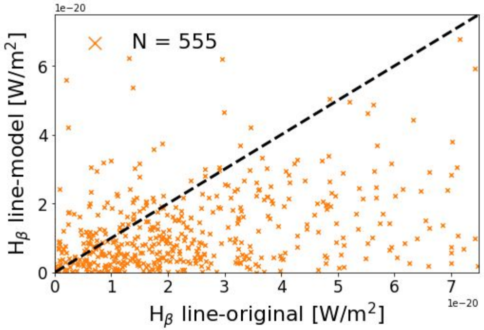
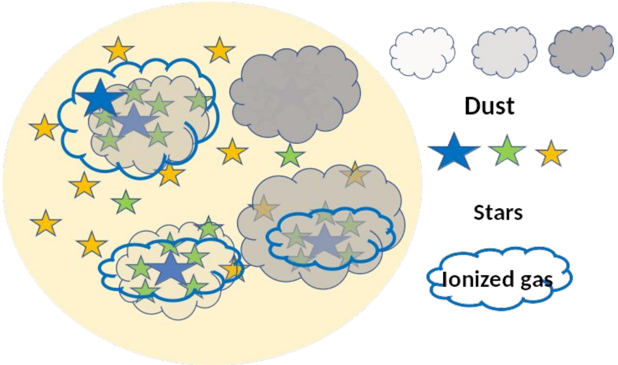
Current and Future work ...





Accurate recipes for attenuation



Simulation of realistic SEDs from realistic photometry

Numerical simulations of SEDs

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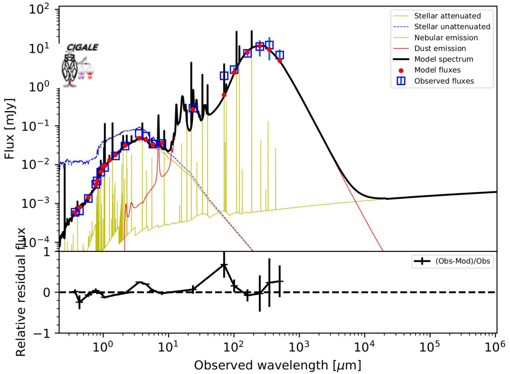
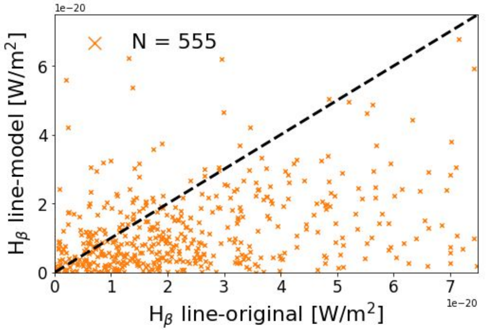
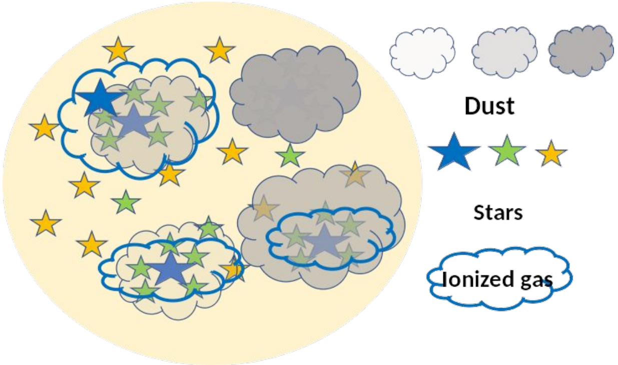
Current and Future work ...





Accurate recipes for attenuation

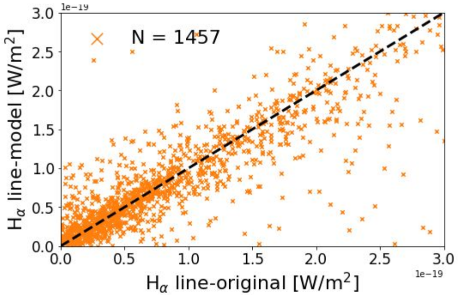


Simulation of realistic SEDs from realistic photometry

Numerical simulations of SEDs

MOONS DR1

Better fits for emission lines



Summary

- **CIGALE** can perform **SED** fitting using simultaneously photometric and spectroscopic data .

- There is a current **CIGALE-MOONS** version including **SSP HR-models** which will evolve to be adapted for **MOONS** requirements in the future.

- **Hβ** emission line is currently hard to fit with a simple model available in **CIGALE**. Modifying the recipe for emission line calculation and/or attenuation laws will solve this issue and pave the road for **MOONS** measurements.

- We need instruments like **MOONS** to create better photo-spectroscopic samples because the current **3D-HST** data available for fields which are well known are not sufficient. **MOONS** will provide a better sample to study dust attenuation, SFR, metallicities, etc....

Thanks

Questions ?

Comments ?

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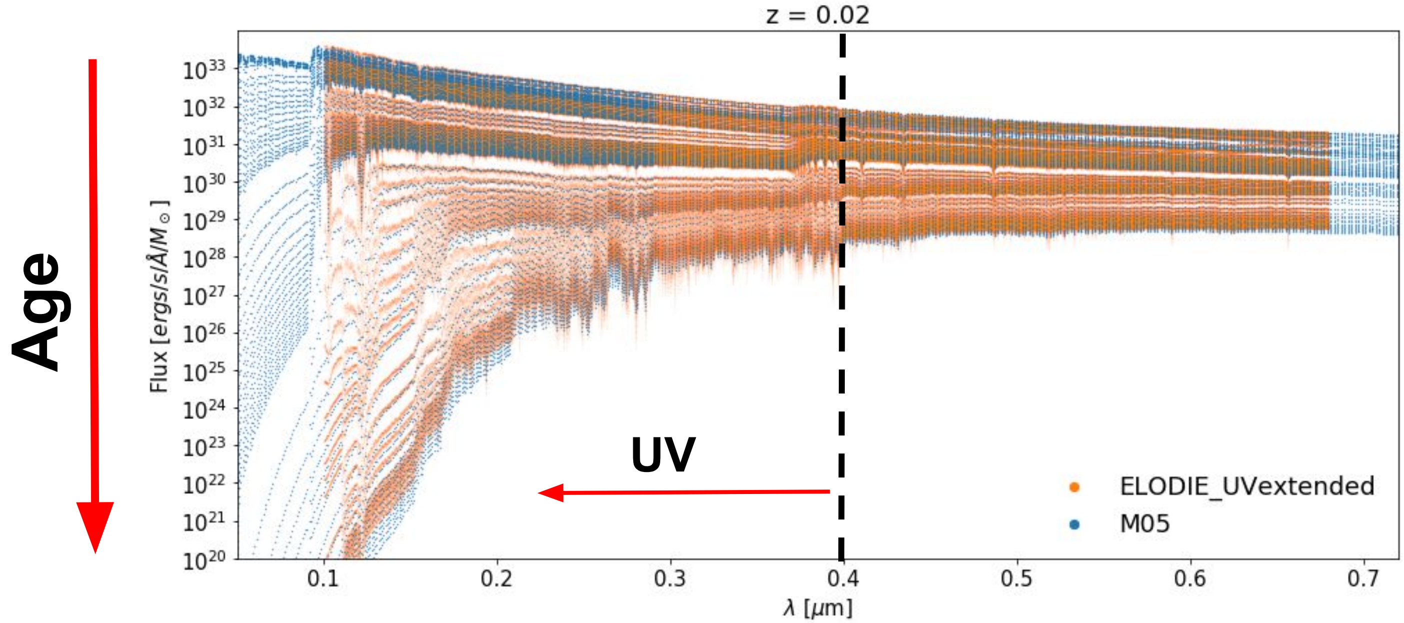
Current SSP models: ELODIE UV-extended



M05:
1000 yr - 15 Gyr
91 - 1600000 [μm]

ELODIE:
3 Myr - 12 Gyr
0.10 - 0.68 [μm]
R = 0.55 Å (FWHM)
IMF - Salpeter

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MOONS Sources Coverage